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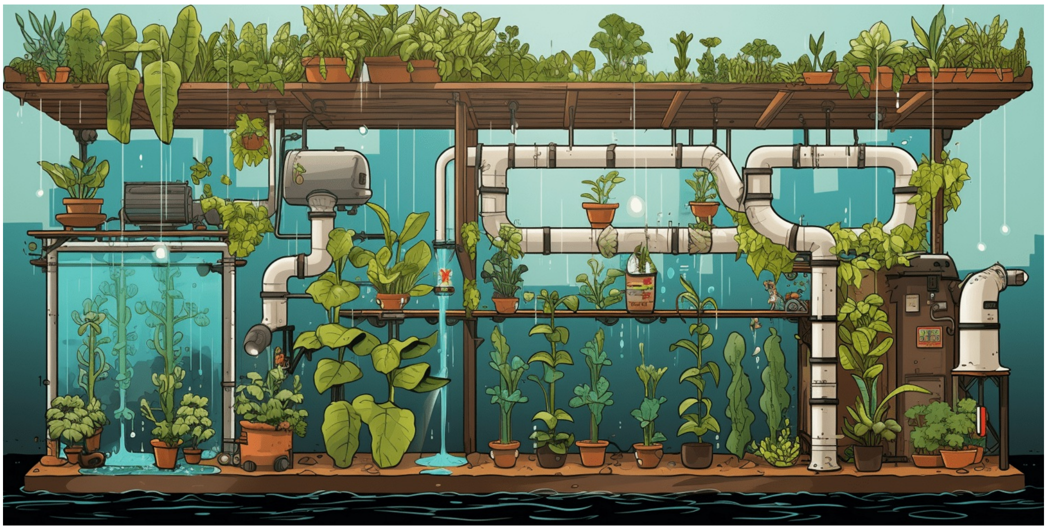

Sustainable Agriculture: Aquaponics-Integrated Greenhouse Cultivation of Cantaloupe with Drip Irrigation System

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Abstract

Aquaponics, a revolutionary agricultural approach, is seamlessly integrated into the greenhouse cultivation of cantaloupe with a drip irrigation system, gaining prominence in Vietnam as a climate-resilient solution. This innovative model ensures year-round cultivation, independence from weather fluctuations, and effective control of pests and diseases. Cantaloupe, rich in nutrients such as provitamin A, vitamin C, vitamin E, and folic acid, thrives in this system. The greenhouse environment minimizes pesticide usage, meeting stringent food safety standards. The successful pilot model, initiated under the project " Investigate, develop, and construct an organic fish and vegetable aquaponics farm model in Ben Tre province, utilizing IoT technologies to monitor and manage environmental conditions", has expanded in Mekong Delta, Vietnam. This approach not only elevates productivity and quality but also proves economically advantageous by optimizing resources and reducing production costs.

Keywords: Agricultural membrane technology, Cantaloupe cultivation, Aquaponics, Greenhouse, Drip irrigation system, Climate change adaptation.

1. Introduction

Agricultural membrane technology is becoming increasingly prevalent in our country, emerging as an effective solution to leverage science and technology in adapting to climate change. This widespread adoption is attributed to the model's distinct positive impacts, including the creation of a favorable agricultural environment independent of climate factors. This approach empowers farmers to proactively manage the planting process, mitigating risks associated with weather abnormalities and pests, ultimately enhancing both productivity and quality.

Cantaloupe (Cucumis melo L.), a fruit vegetable belonging to the Cucurbitaceae family, exhibits a short growing period, robust growth rate, prolific branching, and high yields, making it suitable for multiple seasons of cultivation. Rich in essential nutrients such as provitamin A (β-carotene), vitamin C, vitamin E, and folic acid, cantaloupes serve as vital antioxidants in human nutritional metabolism. Greenhouse cultivation of cantaloupe proves advantageous as it limits pests and diseases by providing controlled environmental conditions. This method ensures year-round production, overcoming dependence on natural conditions and reducing seasonality.

The greenhouse approach minimizes pesticide use, aligning cantaloupe products with stringent food safety standards, meeting the rising demands for high-quality food. Integrating a drip irrigation system further enhances resource efficiency, maximizing savings while optimizing nutrient delivery and water usage for cantaloupes. This dual strategy contributes to reducing production costs and increasing profits for the model.

Building upon a scientific foundation and practical application, a pilot production model for growing cantaloupe in a greenhouse was established during the implementation of the project *"Investigate, develop, and construct an organic fish and vegetable aquaponics farm model in Ben Tre province, utilizing IoT technologies to monitor and manage environmental conditions"* This successful model has not only been sustained but has also expanded to an additional min 1800m^2 in Ben Tre, Vietnam. The implementation team shares the achieved results, highlighting the viability and success of this innovative cantaloupe cultivation approach in Ben Tre province.

2. Methods of Implementation

2.1. Location and time of project model implementation

2.1.1. Location where the model is implemented

The project is executing a cantaloupe cultivation model within greenhouses equipped with a drip irrigation system. This project is being implemented at Long Gia Trang (Point 1), An Dinh Commune, Mo Cay Nam District, Ben Tre Province, and at "Người Giữ Rừng" (Point 2), located in Thạnh Phước Commune, Bình Đại District, Ben Tre Province. Each greenhouse at the implementation sites covers an area of min 500m^2. The selection of these two locations is based on their favorable transportation conditions, facilitating the transportation of materials and construction processes. The planting sites offer spacious areas, allowing for the incorporation of various auxiliary facilities such as warehouses for raw material and fertilizer storage and spaces for substrate mixing and incubation.

2.1.2. Time and scale of model implementation

The model of growing cantaloupe in a greenhouse using a drip irrigation system is arranged in 03 growing seasons with the following quantity and time:

Table 1. Scale and implementation time of melon growing seasons

Planting season	Alike	Scale	Execution time	Note	
Case 1	Taki	2,600 trees	From December 2020 to February 2021	Record productivity data	
Case 2	Taki	2,600 trees	From May 2021 to July 2021		
Case 3	Taki, Inthanon RZ and Hami	2,600 trees (Taki variety 800 trees, Inthanon RZ variety 500 trees + Hami variety 1,300 trees)	- Planting Long Gia Trang Point: from March 2022 to May 2022. - Planting “Người Giữ Rừng" Point: from April 2022 to June 2022.		

To have a basis for evaluating the effectiveness of the growing process in the project while increasing the ability to sell project products to meet consumer needs, different varieties of cantaloupes are proposed for trial planting in each unit. greenhouse location in the third crop (Table 1).

2.2. Technical measures for constructing and installing greenhouses and operating drip irrigation systems

2.2.1. Construction of greenhouses

For the model implementation location in Ben Tre provice, the project at Point 1 has considered choosing the design and construction of a membrane house to grow melon with an area of 500m2 (58.2m long, 8.6m wide) according to Dome style with prefabricated steel frame material, covering membrane is specialized PE membrane; Installed electricity and water supply systems; Ventilation fan system adjusts the temperature inside the greenhouse when necessary; cable car system and other auxiliary items. Construction time is about 30 days. For the model implementation location at Point 2, the current status is that there is 01 net house of more than 850m2 with 02 sloping roofs, with a system Complete electricity and water supply system; The project conducts design and construction to renovate a greenhouse to grow melons, implementing renovation items such as: roofing with specialized PE film; Install an additional cable car system to hang melon vines; Install a temperature-controlled ventilation fan system and a number of other ancillary items.

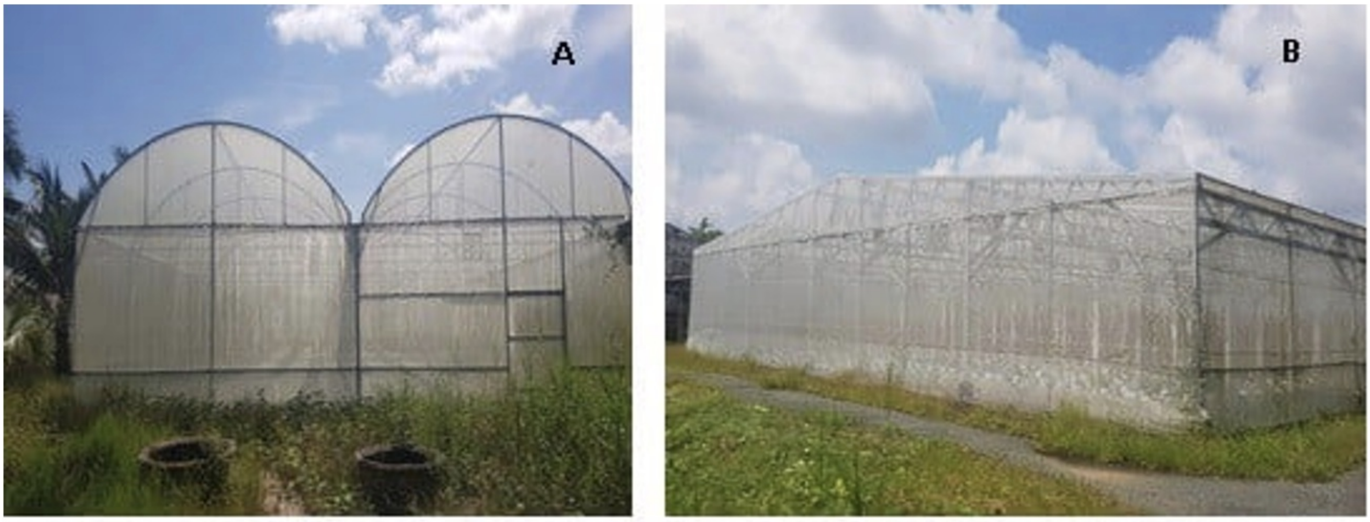

Figure 1. Greenhouses in Poin1 (A) and in Poin 2 (B) in Ben Tre Province, Vietnam, 2022

2.2.2. Install a drip irrigation system

The water source is main pipe leading to the entire garden. The drip irrigation system is designed and constructed as the design diagram below:

- Inverter water pump, 02 pieces; An additional self-opening and closing relay is installed to automatically pump water into the tank. The pumping station system is located near the water source and has enough space to arrange a central controller.
- The filtration system is responsible for removing residue and creating a stable water flow. Create relatively quality water before providing it to plants. Therefore, filter core generation needs to be carried out regularly during the irrigation process.
- 10 bar water pressure gauge. The water pressure gauge is responsible for checking the operation of the pump, the cleanliness of the filter core and water leakage in the pipes. The timer adjusts the watering mode accurately to the second, the electrical cabinet starts from. Venturimetro 1" stool suction set.
- Main pipe/branch pipe system. The main pipe is a 48mm diameter hard PVC pipe to withstand the design pressure in the system. Branch pipes are LDPE pipes with initial valves attached. Accessories for assembling the pipe system include elbows, straight joints, T-joints, pipe diameter reduction joints, butterfly valve pipes and glue to glue the joints. 20mm LDPE irrigation pipe, 1.2mm thick, 4 bar pressure. 4L/h drip head set, 4-wire split port 5cm long.

2.3. Process and technique of growing Cantaloupes

The project's technique of planting and caring for Taki Cantaloupe tested in Ben Tre is applied from the Center's "Technical process for growing Cantaloupe (Cucumis melo L.) on substrate in a greenhouse using drip irrigation". High-tech agricultural research and development [1], recognized by the Department of Crop Production - Ministry of Agriculture and Rural Development of Vietnam as a technical progress in Decision No. 512/QD-TT-CLT in 2014, is described according to the profile diagram and Figure 2 below.

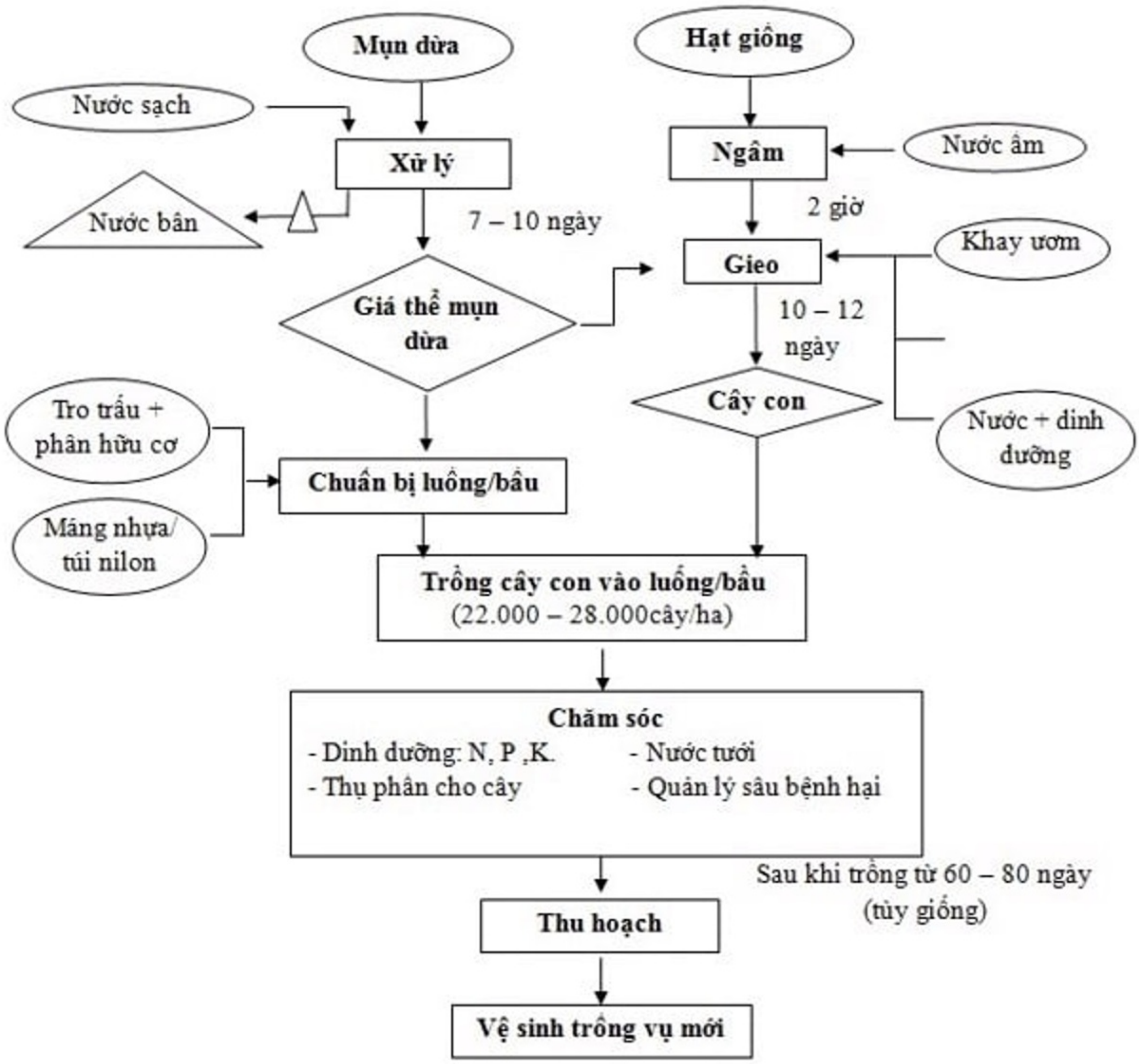

Figure 2. Technical diagram of planting and caring for melon vines, Keep the original and copyright intact.

2.4. Monitor and evaluate indicators of growth, yield and quality of cantaloupe

Growth Criteria:

Plant Height (cm): Recorded every 10 days after planting with 5 random plots, each measuring 05 trees. The average value is calculated from the position of the leaf to the end of the tip.

Number of Leaves: Monitored every 10 days after planting with 5 random plots, each measuring 05 trees. Leaf morphological characteristics such as shape and color are observed to assess plant health.

Fruit: Evaluation includes sensory criteria for fruit shape, skin color, and flesh color.

Indicators on Pests and Diseases:

Composition of Pests and Diseases: Observed visually to identify types present on the plant.

Percentage of Trees Damaged by Pests (%): Calculated as (number of trees damaged by pests/total number of trees monitored) x100. Monitored for all plants in the garden.

Percentage of Diseased Trees (%): Calculated as (number of diseased trees/total number of trees monitored) x100. Monitored for all plants in the garden.

Productivity Targets:

Number of Harvested Fruits: Only one fruit per tree is left, and the total number of fruits in the entire garden is counted to calculate the loss rate.

Average Weight of Fruit (kg): Calculated as harvested yield/total number of harvested fruits.

Actual Yield (kg/1000m2): The entire garden is harvested to calculate the actual yield.

Quality Criteria:

Degree Brix: Measured using a Brix meter.

Flavor: Assessed through sensory tasting.

Crispiness: Assessed through sensory tasting.

Sample Analysis: Cantaloupe samples undergo analysis for food safety indicators during the production process, including heavy metal analysis (Pb, Cd according to QCVN 8-2: 2011/BYT National Technical Regulations, Vietnam), microbial analysis (Salmonella, E.coli according to QCVN 8-3: 2012/BYT National technical regulations for microbial contamination in food), and pesticide residues (according to Circular 50/2016 of the Ministry of Health on regulations on maximum limits of pesticide residues in food).

2.5. Statistical processing method of results

The data is collected through manual recording and tracking using Excel software, inheriting data from previous research. Subsequently, the analytical and statistical data related to the project implementation outcomes are processed utilizing Microsoft Excel software.

Moreover, there is also a smart board designed for drip irrigation using Israeli technology and surveillance cameras imported from China to monitor the area.

3. Results and Discussion

3.1. Seedling stage

The results of monitoring some growth indicators of cantaloupe in the seedling stage are presented in Table 2.

Table 2. Monitoring growth indicators of seedlings

Status	Targets	Targets request	Result perform
first	Number of days of sowing	8 - 10 days	10 - 12 days
2	The height of trees	5 - 7 cm	6 - 7 cm
3	Body diameter	1.5 - 3 mm	1.5 - 3 mm
4	Number of real leaves	02 leaves	02 leaves
5	Loss rate (seeds do not germinate or grow slowly)	-	5 - 10 %

The results recorded in Table 2 show that, on average, seedlings nursed for 11 days will meet the standards for seedlings to be planted. The condition of the seedlings when planted in the polybag is healthy, not deformed, the tops are well developed, and there are no signs of pest infection (Figure 3). Through actual observation, it takes 10 to 12 days for seedlings to have 2 complete true leaves and meet the required criteria. Meanwhile, after 8-10 days of sowing, the second true leaf only begins to appear. The reason may be because at this stage the plant uses nutrients mainly from embryos and the root system is still weak, so this process is only Add water, do not add nutrients. This result is consistent with the requirement for time to sow melon seeds before planting according to the recommended process of about 10 - 15 days [1][2]

Figure 3. (A) 8-day-old seedlings; (B) Seedlings are qualified for planting.

From the results of nursery seedlings as above, it also shows that the average loss rate (seeds do not germinate or grow slowly) is about 7.5%. Therefore, in actual production, the seed nursery process should arrange an additional nursery of about 7.5 - 10% of the number of seeds to be planted, to compensate for the seeds that do not germinate, or the seedlings do not develop up to the mark. pepper growth before planting.

3.2. Stage after planting

Monitoring the growth and development process of cantaloupes for 30 days after planting, the results recorded a number of indicators calculated on average as shown in Table 3 below.

Table 3. Monitoring growth and development indicators of cantaloupe

Growth index	Dry season	Rainy season			
	Case 01 (December 2020 - February 2021)	Case 02 (May 2021 - July 2021)	Case 03 (March 2022 - June 2022)		
	Taki	Taki	Taki	Inthanon RZ	Hami
Number of plants	2,600	2,600	800	500	1,300
The height of trees	1.79 m	1.74 m	1.75 m	1.78 m	1.79 m
Number of leaves on the tree	29	28	29	30	30
Harvest date	60 NST	60 NST	60 NST	65 NST	75 NST

From the results in Table 3, it shows that cantaloupe adapts, grows and develops well in experimental planting conditions in Ben Tre province. The average index of tree height and number of leaves/tree always grows steadily. Comparing with published documents on the melon growing process [3][4][5], the project melons planted in Ben Tre show similarities in growth and development speed.

Crops 02 and 03 are arranged during the rainy season, the greenhouse is covered with a PE roof so that the melons are not affected by the weather. Results of monitoring the growth and development of cantaloupe in the rainy season show that the average growth and development rate of cantaloupe is no different from that of cantaloupe grown in the dry season. The results also showed that different cantaloupe varieties will have different harvest times, specifically the Taki variety is 60 chromosomes, the Inthanon RZ variety is 65 chromosomes, and the Hami variety is 75 chromosomes.

Monitoring results of harmful pests and diseases on cantaloupes are listed in Table 4

Table 4. Rate of diseases on plants

Disease name	Dry season	Rainy season			
	Case 01 (December 2020 - February 2021)	Case 02 (May 2021 - July 2021)	Case 03 (March 2022 - June 2022)		
	Taki	Taki	Taki	Inthanon RZ	Hami
White chalk	61.03%	0%	0%	0%	0%
Missed root collar	2.61%	1.96%	3.87%	3.6%	4.07%
Left ass rot	1.11%	0.5%	1.87%	2.8%	3.76%

Monitoring results in Table 4 show that, during the experimental growing process, no pests were detected on the melon. This result shows that greenhouses play a great role in preventing pests on melon plants. However, due to seasonal factors, cantaloupes encounter some harmful diseases such as leaf fungus, fruit rot, powdery mildew, and root rot (Figure 4 - 6).

The first cantaloupe crop grown in the dry season had the highest rate of plants infected with powdery mildew (61%), however powdery mildew did not appear in the remaining cantaloupe crops grown in the rainy season (Table 4). The cause of powdery mildew disease in melons was determined to be due to seasonal factors grown in Ben Tre; At the time of planting the first crop (between October and December of the lunar calendar), there is little daylight and high air humidity (> 80%), which are also ideal conditions for fungal growth. This outcome bears similarities to findings observed in certain locations within the Mekong Delta, such as Tra Vinh, Sóc Trăng, and Cà Mau. It aligns with reported results from a melon cultivation model in Tra Vinh, indicating that planting melons from October 2021 to January 2022 resulted in a higher incidence of fungal infections compared to planting from December 2020 to March 2021. [6]. Powdery mildew primarily affects the leaf blades, manifesting initially as normal green spots on the leaves. Over time, these spots transition to a yellow hue, with the lesions gradually expanding and becoming covered by a dense layer of fungus resembling fine white powder. Notably, in the first crop, the concentration of powdery mildew was observed during the 45-60 day period when the trees were bearing fruit, coinciding with the peak density of trees in the garden.

The tested cultivars exhibited a minimal incidence of plants affected by root rot and fruit rot, fluctuating between 1-4% (Table 4). The occurrence was higher in the third crop compared to the first and second crops. The practice of reusing the growing medium contributes to a heightened presence of pathogens, subsequently increasing the incidence of root collar disease in subsequent planting seasons.

To mitigate fungal diseases, it is essential to enhance ventilation within the garden by pruning side shoots and leaves while carefully managing water levels to prevent excess moisture. Periodic application of fungicides on both leaves and roots is recommended, utilizing Ridomi Gold, Aliete, and Coc 85 in alternation as per instructions. In cases of root rot disease, a treatment approach involves a thorough application of a mixture containing concentrated Ridomi Gold (50%) evenly onto the affected stems.

Figure 4. Taki tree with powdery mildew disease.

Figure 5. Tree with root rot disease

Figure 6. Tree with left end rot

Based on direct observations during the planting period, Taki melons frequently succumb to adverse weather conditions and high humidity, rendering them susceptible to powdery mildew disease, which tends to proliferate swiftly. Conversely, melon varieties Inthanon RZ and Hami exhibit no signs of fungal diseases on the leaves; however, instances of root rot and fruit rot manifest in this particular cultivation model. It is imperative to conduct further comprehensive testing on these two melon varieties to establish a scientific foundation for evaluation and subsequent recommendations to the farming community.

3.3. Results on yield and quality of cantaloupes

a) Evaluation of productivity

Statistics on the average results of harvesting experimentally grown melon products are listed in Table 5.

Table 5. Evaluation of cantaloupe harvest yield (~1,000m ^{2} greenhouse)

Targets	Dry season	Rainy season		Average
	Case 01 (December 2020 - February 2021)	Case 02 (May 2021 - July 2021)	Case 03 (March 2022 - June 2022)	
Number of harvested fruits (fruits)	2,380	2,430	2,306	7,116
Average weight (kg/fruit)	1.28	1.43	1.55	1.42
Productivity (tons/1,000m2/crop)	3,047	3,474	3,565	3,362
Total output (kg)	3,047.4	3,474.8	3,565.4	10,087.6
Rate of type 1 fruit (%)	85	89	95.5	89.83
Loss rate (%)	8.46	6.53	11.3	8.76
Degree Brix	>13	>13	>13	>13

Throughout the monitoring of three experimental planting seasons of cantaloupe, the cumulative yield reached 10,087 kg, averaging 3,362 tons/1,000m2 per crop. The average weight per fruit was 1.42 kg, with approximately 89.83% classified as type 1 fruits. The overall loss rate, encompassing factors such as failure to set fruit, diseases, and fruit rot, stood at 8.76% (refer to Table 5).

In the first crop, some melon vines exhibited uneven fruit development, and certain vines produced fruits with unsatisfactory weight (less than 1.3 kg per fruit), accounting for a 15% higher rate than the subsequent crops. This discrepancy can be attributed to inappropriate row spacing in the planting site at Long Gia Trang of Ben Tre. The dense planting arrangement hindered sufficient sunlight exposure during the day, compounded by adverse weather conditions, including limited daylight hours and high air humidity (>80%), from December 2020 to January 2021.

In crops 02 and 03, adjustments were made to the planting beds to ensure optimal light intensity and duration for the well-being of melon growth. Simultaneous flowering and pollination treatments were conducted, resulting in increased productivity and efficiency. Notably, in crop 03, various new varieties were tested and encountered diseases (root rot, fruit rot), leading to a higher loss rate compared to other crops. However, the Hami variety, despite being affected, exhibited a higher fruit weight than other varieties, contributing to the surpassing of the project target in crop 03. These diverse varieties, sourced from different suppliers with varying optimal weights, align with findings from prior studies and publications [4][7][8].

Comparing and comparing with some melon growing models in other provinces, the experimental melon growing model in Ben Tre shows highly similar yield results. Specifically, the model in An Giang belongs to the project "Application of greenhouse technology and drip irrigation system in Taki melon production in Long Xuyen city, An Giang" of the City Plant Cultivation and Protection Station. Long Xuyen implemented it in 2018 with results over 02 crops with an average yield of 3,550kg/1,000m2/crop, average weight of 1.47kg [9].

Or the model in Tra Vinh belongs to the grassroots project "Building a safe model of growing cantaloupe in a greenhouse using drip irrigation technology in Tra Vinh province" of Tra Vinh Center for Science and Technology Information and Application. implemented in 2020, the yield of Taki and ML38 melons is 1,202kg/384m2/crop, the average fruit weight is 1.4kg [6].

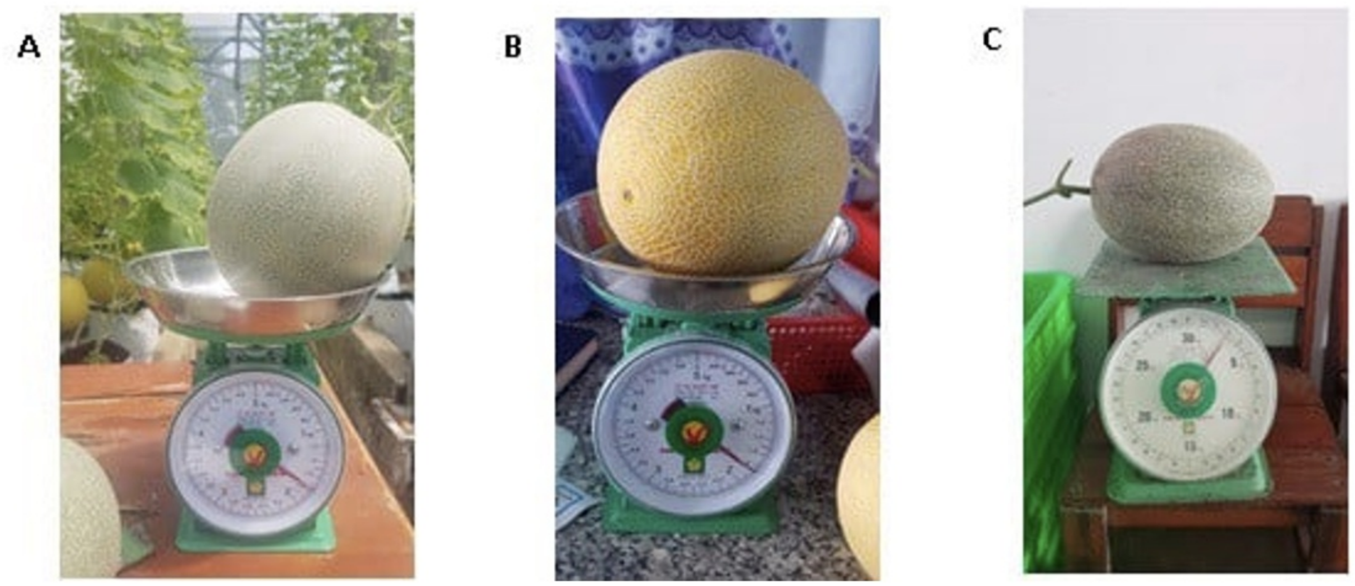

Figure 7. Weight of some typical cantaloupes in the model: (A) Taki 1.75 kg, (B) Inthanon RZ 1.8 kg, (C), Hami 2.8 kg

b) Quality assessment

- Sensory evaluation:

Through evaluation, sensory comments of consumers and results of product sample analysis, it shows that delicious and sweet cantaloupe products are favored by consumers.

Table 6. Sensory assessment of quality of cantaloupe varieties

Alike	Peel color	Fruit shape	Fruit flesh color	Crispness of fruit flesh	Smell
Taki	Dark green with thick mesh pattern	Evenly round	Orange	Slightly crunchy	Fragrant
Inthanon RZ	Golden, thick mesh pattern	Oval	Green	Crispy	Fragrant
Hami	Dark green, thick mesh pattern	Oval	Orange	Crispy	Fragrant

The Taki and Hami varieties exhibit a dark green skin color with pronounced mesh patterns, while the Inthanon RZ variety features a yellow-white fruit skin. The fruit flesh of the Taki and Hami varieties is characterized by its orange hue, whereas the Inthanon RZ variety presents green flesh (refer to Figure 8). Varied fruit flesh colors indicate differences in nutrient content within the fruit. The crispness of the fruit flesh is a pivotal characteristic influencing the quality and taste preferences of consumers. Typically, older individuals prefer softer fruit flesh, while younger individuals lean towards a crunchier texture. The Taki variety possesses slightly crispy flesh, whereas the remaining varieties boast a crisp texture. Choosing varieties that cater to the preferences of individuals across different age groups holds significant importance.

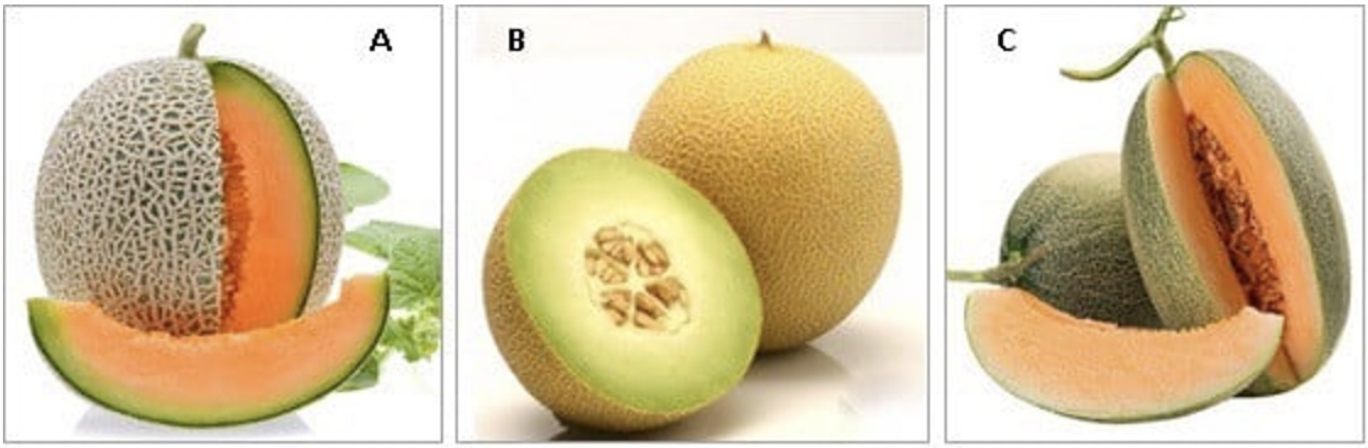

Figure 8. Flesh morphology of Taki (A), Inthanon RZ (B) and Hami (C) melons when harvested

- Product quality analysis:

Experimentally grown cantaloupe products were sampled and analyzed for Brix (sweetness) criteria. Taki varieties were analyzed for food safety criteria including: microorganisms, heavy metals and drug residues. Plant protection (Table 7). As for Hami and Inthanon RZ varieties, they were grown for additional testing, so no analysis of food safety criteria was performed, only Brix measurements were performed.

Table 7. Analytical results of Taki melon product

Status	Targets	Result	Analytical methods *	Note
first	Degree Brix	15	Measured with a Brix meter	
2	Microorganism			Compare Decision No. 46/2007/QD-BYT (section 6.6.1)
-	E.coli	Not detected	TCVN 6846:2007	Obtain
-	Salmonella sp.	Not detected	TCVN 10780-1:2007	Obtain
3	Heavy metal			Compare QCVN 8-2: 2011/BYT (maximum level)
-	Pb	0.035 mg/kg	AOAC 999.11	0.1 - Pass
-	CD	0.031 mg/kg	AOAC 999.11	0.05 - Pass
4	Pesticide residues			Compare circular number: 50/2016/TT-BYT
-	31 criteria for pesticide residues for all types of melons, except watermelon	Not detected	LC/MS/MS	Obtain
-	Carbamate pesticide residue	Not detected	LC/MS/MS	Obtain
-	Organophosphorus pesticide residues	Not detected	LC/MS/MS	Obtain

**Note: The sample analysis unit is the Ben Tre Provincial Analysis and Testing Center.*

The brix level of fruit flesh is the main trait that determines the quality of cantaloupe. All three cantaloupe varieties have high Brix levels at harvest time (>13). The Brix level will gradually increase due to dehydration and the decomposition of organic compounds in cantaloupe becomes stronger during storage [9]. The brix level of cantaloupe varieties in this model is higher than that of cantaloupe varieties in the research results of Tran Thi Ba et al. [10] or by Truong Thi Hong Hai et al. [7]. The reason may be because the harvest time of the project model is when the fruit stem cracks, because the melons at this harvest time have good taste, acid and sugar content much better than those harvested at other locations. At other times, the Brix level reaches its optimal potential so that the product can meet consumers' sweetness requirements [3].

In addition, 02 melon production facilities in the project's pilot model were also granted Certificates of establishments meeting food safety conditions by the Ben Tre Department of Crop Production and Plant Protection according to Circular No. 38/2018/ TT-BNNPTNT dated December 25, 2018 of the Ministry of Agriculture and Rural Development, Vietnam.

Through the summary of 03 experimental cantaloupe growing seasons, it shows that the quality of cantaloupe products is fragrant, delicious, and meets safe food standards, so they are consumed through many forms such as: consumption in Co.opmart Supermarket, Co.opfood Ben Tre, sells wholesale and retail to people, sells to agencies and units as gifts during Tet holidays, sells to visitors to the melon garden, with the selling price of cantaloupe products ranging from 40,000 VND. - 60,000 VND/kg, thereby helping the product have a stable output.

5. Conclusions and recommendations

4.1. Conclusion

Based on the outcomes derived from implementing the greenhouse cultivation model for cantaloupes coupled with a drip irrigation system, the initial conclusions are outlined as follows:

Production Arrangement and Organization Methodology:

Components encompassing the greenhouse, irrigation system, substrate, and nutrition have been effectively organized.

The technical process employed for planting and caring for cantaloupes is well-suited for the cultivation of the Taki variety and other variants, such as Inthanon RZ and Hami.

Melon Yield and Project Output:

The average melon yield attains 3,362 tons/1,000m2/crop.

The total melon output for the project achieves 10,087 tons, surpassing the project target by 112%.

Type 1 products constitute 89.83% of the output, exceeding the project target by 105.68%.

The average weight of melon fruit is 1.42kg, exceeding the project target by 109.23%.

Brix level ≥13 meets the project target at 100%.

Food Safety Certification:

Both cucumber cultivation facilities involved in the project were implemented during the Covid-19 pandemic, with the team in a period of isolation. Therefore, the project was conducted as individual research and did not receive any sponsorship.

Training Initiatives:

Despite modest results, the project aims to organize training sessions for learners, particularly farmers, on greenhouse cucumber cultivation techniques and the application of safe drip irrigation systems. The training also covers knowledge about establishing and registering agricultural production facilities to ensure food safety in the context of climate change, focusing on indigenous plant varieties.

Documentation Adjustments:

The project has also revised and supplemented instructional documents to enhance the technical process of greenhouse cucumber cultivation and the application of a suitable drip irrigation system for production conditions in Ben Tre province. This adaptation is specifically tailored to the farming of indigenous livestock such as carp, tilapia, catfish, etc., and native vegetables including sweet cabbage, lettuce, and various local herbs.

4.2. Request

Highlighting the significance of Aquaponics in climate change adaptation in Ben Tre, this innovative agricultural method shows potential for integration with tourism and environmental education. The melon growing season in greenhouses, taking place from October to December in the lunar calendar, faces susceptibility to diseases influenced by Ben Tre's weather conditions. It is crucial to explore additional disease prevention measures or consider crop rotation during this period to mitigate the impact of harmful fungi.

Taki melon plants exhibit strong adaptation, growth, and development under experimental planting conditions in Ben Tre. Both Inthanon RZ and Hami cantaloupes demonstrate favorable adaptation and yield well under production conditions. However, a comprehensive assessment of yield and quality specific to Ben Tre is crucial, requiring further extensive testing of these varieties before providing recommendations to farmers.

Continued monitoring and implementation of the model across multiple crops (3 crops/year) are essential for enhancing economic efficiency. Simultaneously, the model should be extended to various cantaloupe varieties to refine the indoor melon growing process and diversify cantaloupe products to align with consumer preferences.

Upon project completion, widespread deployment and replication of the model at all levels and sectors are crucial to supporting the transition in agricultural production methods. This involves leveraging scientific and technical advancements to ensure both production efficiency and environmental protection.

During the replication of the model, it is imperative to establish a production linkage model, fostering connections along the agricultural value chain and product consumption through contractual agreements between businesses and farmer households. This approach ensures the stability and sustainability of the production model. Furthermore, diversification through various forms of product consumption, such as supermarket chains, convenience stores, online sales, and retail sales combined with tourism, is critical for maximizing the value and profits of the model.

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